SEAMLESS HIGHLIGHTING IN LCD MONITORS AND LCD-TV

TECHNICAL FIELD

The technical field of this disclosure is liquid crystal display panels, particularly, a liquid crystal display panel providing rapid highlighting.

BACKGROUND OF THE INVENTION

Liquid crystal display (LCD) panels have developed as an alternative to cathode ray tubes (CRTs), offering the advantage of a thin profile and brilliant display. LCD panels have been used for a number of applications, including computer monitors and television displays.

One highly desirable feature for displays is the ability to highlight a portion of a display at a brighter intensity for easier viewing. For example, a computer user may wish to use a cursor to delineate a portion of a picture on a display and brighten that portion for easier viewing. In another example, a computer or television user may want to view one program in the main display and another program in an inset window. The two programs may require different amounts of lighting: a simple, high contrast subject such as text can be easily seen, but a complex subject such as video may require brighter intensity lighting. Highlighting the complex subject makes it easier to see.

LCD panels have lagged CRTs in highlighting functionality. LCD panels typically use one or two fluorescent lamps, such as a mercury vapor cold cathode fluorescent lamps (CCFLs), to provide a uniform backlighting of the LCD panel. CRTs are able to quickly highlight a portion of the display by increasing beam energy, while LCD panel highlighting lags due to the time required to increase the backlight lamp temperature. Individual liquid crystal (LC) elements control the brightness of specific areas of the LCD panel. The lamps must be at the full brightness level before the LC elements can provide the proper highlighting.

For the present generation of LCD panels possessing a highlighting function, the lamps normally operate at 50% lamp current and light output during conditions of non-highlighting. The lamp is stepped to 100% lamp current when highlighting is required. Because of the thermal lag in the lamp, there is visible delay of 10 to 20 seconds before the lamp reaches 100% light output. This is undesirable, as the user must wait for the highlighting to appear. The user may even think that the delay indicates a problem with the display or the computer.

FIG. 1 shows a graph of a step increase in lamp current and the delay in lamp light output. The lamp current is initially 50% and the lamp light output is initially 50%. When the user requests highlighting, the lamp current is increased to 100% and the light output gradually increases from 50% to 100% over 10 to 20 seconds. The user must wait the 10 to 20 seconds before the highlighting is effective.

It would be desirable to have a liquid crystal display panel providing rapid highlighting that would overcome the above disadvantages.

SUMMARY OF THE INVENTION

One aspect of the present invention provides a liquid crystal display panel providing rapid highlighting without a substantial delay.

Another aspect of the present invention provides a liquid crystal display panel providing rapid highlighting that reduces the user waiting time.

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention, rather than limiting the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a graph of a step increase in lamp current and the delay in lamp light output.

FIG. 2 shows a block diagram of a liquid crystal display panel system made in accordance with the present invention.

FIG. 3 shows a graph of lamp current and light output for a liquid crystal display panel applying an intermediate current made in accordance with the present invention.

FIG. 4 shows a graph of lamp current for an alternate embodiment of a liquid crystal display panel applying an intermediate current made in accordance with the present invention.

FIG. 5 shows a graph of lamp current for yet another alternate embodiment of a liquid crystal display panel applying an intermediate current made in accordance with the present invention.

FIG. 6 shows a graph of lamp current for yet another alternate embodiment of a liquid crystal display panel applying an alternate intermediate current to leave the highlighting mode made in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The liquid crystal display panel of the present invention provides rapid highlighting of the display. To provide highlighting, current to the backlighting lamp is increased from a normal current to a highlighting current. During the transition from the normal current to the highlighting current, the current to backlighting lamp is increased to an intermediate current above the highlighting current, and then decreased to the highlighting current. The increase to an intermediate current provides greater energy to the backlighting lamp than a direct increase from the low current to the highlighting current. The increased energy heats the backlighting lamp quickly to provide the increased light for highlighting. In addition, reducing the current to the backlighting lamp below the normal current when leaving the highlighting mode decreases the time to leave the highlighting mode.

FIG. 2 shows a block diagram of a liquid crystal display panel system made in accordance with the present invention. Liquid crystal display (LCD) panel **12** having a highlight section **14** is backlit by lamp **10**. Liquid crystal (LC) driver **16** controls the liquid crystal array of the LCD panel **12**. Power supply **20** supplies DC power to inverter **18**, which provides current to the lamp **10**. User interface **22** controls the LC driver **16**, the inverter **18**, and the power supply **20**.

Liquid crystal display (LCD) panel **12** can be a conventional LCD panel comprising an array of pixels. The pixels further comprise liquid crystal shutters to adjust brightness from each particular pixel, and can have color filters to provide a color display. The liquid crystal shutters are controlled by the LC driver **16**. The liquid crystal shutters of the highlight section **14** are more open than the liquid crystal shutters in the rest of the LCD panel **12** to provide the additional brightness required for highlighting.

Lamp **10** provides backlighting for the LCD panel **12** so that the light is transmitted through the pixels to the user. Typically, the lamp **10** can be one or more fluorescent lamps, such as mercury vapor cold cathode fluorescent lamps (CCFLs). The lamp **10** can also be provided with a light guide to direct the light and assure uniform backlighting behind the LCD panel **12**. The lamp **10** typically operates at a low power level, such as 50% light output, during normal operation and at a high power level, such as 100% light output, when highlighting is requested by the user. The highlight section **14** can be formed with the lamp **10** operating at the high power level and the LC driver **16** opening the shutters for the pixels in the highlight section **14**. In one embodiment, the highlight section **14** can cover the whole display of the LCD panel **12**.

Power unit **19** comprises power supply **20** and inverter **18**, and provides the power to the lamp **10**. The power supply **20** produces a DC output voltage to feed the inverter **18**, which produces an AC output for the lamp **10**. The power supply **20** and inverter **18** can be used separately or in combination control the current to the lamp **10**. The power supply **20** can adjust the DC output voltage to the inverter **18** to provide the desired amount of current to the lamp **10**. The inverter **18** can adjust the frequency, phase, pulse width modulation, or a combination of these parameters, to adjust the current to the lamp **10**. The power supply **20** and inverter **18** are commercially available and are well known to those skilled in the art.

User interface **22** accepts the highlighting request from the user and coordinates the highlighting of the LCD panel **12**. The user interface **22** can be a controller, such as a computer or a microprocessor. The user interface **22** can be a single component or be distributed among several components. The user interface **22** directs a control signal to one or both of the inverter **18** and the power supply **20** to provide the proper current to the lamp **10**. The user interface **22** also directs the LC driver **16** through highlight area control signals to adjust the liquid crystal shutters of LCD panel **12** to provide highlighted and non-highlighted regions, as desired by the user. Transitions to and from the highlighted mode, including intermediate currents to the lamp **10**, are also controlled by the user interface **22** through intermediate control signals to the inverter **18** and the power supply **20**.

FIG. 3 shows a graph of lamp current and light output for a liquid crystal display panel applying an intermediate current. The lamp current is initially at the low current of 50% and the lamp light output is initially 50%. When the user requests highlighting at the user interface, the user interface directs the inverter and/or power supply to increase lamp current to an intermediate current above the highlighting current of 100% then to decrease lamp current to the highlighting current of 100%. In this embodiment, the intermediate current is a step to a peak value with a decrease from the peak

value as an exponential decay such as an RC (resistor-capacitor) circuit can produce. The light output of the lamp increases rapidly from 50% to 100% over about 5 seconds, at which time the highlighting is effective. On receiving the highlighting request, the user interface also directs the LC driver to adjust the liquid crystal shutters to form the highlighted section. The dashed lines illustrate the 10 to 20 second highlighting delay associated with a conventional LCD panel system, where the current is increased directly from the low current to the highlighting current.

Lamp characteristics determine how quickly highlighting can be achieved. While it is desirable to provide as much current to the lamp as possible to maximize heating and minimize time to achieve highlighting, too great a current can damage the lamp electrodes. The magnitude of the peak value and the current as a function of time consistent with preservation of lamp lifetime can be determined through experiment or calculation. In other embodiments with light output feedback, the magnitude of the peak value and the current as a function of time can be controlled by a feedback loop which attempts to obtain the desired light level as quickly as possible.

FIGS. 4 and **5** show graphs of lamp current for alternate embodiments applying alternate intermediate currents. Referring to **FIG. 4**, the lamp current is initially at the low current of 50%. When the user requests highlighting at the user interface, the user interface directs the inverter and/or power supply to increase lamp current to an intermediate current above the highlighting current of 100%, hold the lamp current at the peak value for a predetermined time, then to decrease lamp current substantially linearly to the highlighting current of 100%. Referring to **FIG. 5**, the lamp current is initially at the low current of 50%. When the user requests highlighting at the user interface, the user interface directs the inverter and/or power supply to increase lamp current to a peak value above the highlighting current of 100% along a predetermined curve and then to decrease lamp current along the predetermined curve to the highlighting current of 100%. The curve can be determined to maximize the area A under the curve within the constraint of

electrode current handling capability, i.e., avoiding severe electrode sputtering. This approach delivers the maximum energy to the lamp, providing the fastest warm-up and quickest highlighting.

FIG. 6 shows a graph of lamp current for an alternate embodiment applying an alternate intermediate current to leave the highlighting mode. The above discussion of going from the normal mode to the highlighting mode, i.e., going from 50% to 100% lamp current, applies equally to going from the highlighting mode to the normal mode, i.e., going from 100% to 50% lamp current. Taking the lamp current to an intermediate value less than the target low current of 50% can achieve the normal mode more quickly than taking the lamp current directly to the 50% value.

Referring to **FIG. 6**, the lamp current is initially at the highlighting current of 100% so that the lamp light output would be 100% in the highlighting mode. When the user requests termination of highlighting at the user interface, the user interface directs the inverter and/or power supply to decrease lamp current to an intermediate current below the low current of 50%, hold the lamp current at the minimum value for a predetermined time, then increase lamp current to the low current of 50%. The light output of the lamp decreases rapidly from 100% to 50%, at which time the highlighting ends. On receiving the highlighting termination request, the user interface also directs the LC driver to adjust the liquid crystal shutters to remove the highlighted section.

It is important to note that **FIGS. 2 – 6** illustrate specific applications and embodiments of the present invention, and are not intended to limit the scope of the present disclosure or claims to that which is presented therein. For example, numerous variations in the shape and magnitude of the lamp current versus time curve can be used to good effect. Lamp current can be varied by changing voltage, frequency, phase, or pulse width modulation, alone or in combination. The low and highlighting lamp current can be selected as values other than 50% and 100% and in different ratios than 1:2. Upon reading the specification and reviewing the drawings hereof, it will

become immediately obvious to those skilled in the art that myriad other embodiments of the present invention are possible, and that such embodiments are contemplated and fall within the scope of the presently claimed invention.

While the embodiments of the invention disclosed herein are presently considered to be preferred, various changes and modifications can be made without departing from the spirit and scope of the invention. The scope of the invention is indicated in the appended claims, and all changes that come within the meaning and range of equivalents are intended to be embraced therein.